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2. Project Layout, Description and Basic Data

2.1 Project Location and site

The Itaipu Dam and the works appertaining to it are located 14 km north of Ciudad Presidente Stroessner in Paraguay and Foz do Iguaçu in Brazil. At the project site the Paraná River flows almost due south and is about 400 m wide at average flow conditions. At the streambed level, the river channel is about 250 m wide.

From the streambed at El. 40*, the two banks rise at approximately 45° for a height of about 130 m. Above that, on both banks the terrain is quite flat rising gradually from El. 170 to El. 230.

Because of the relatively flat plateaus, it was possible to provide excellent access to the project site from the cities in the south by highways on both sides of the river. The airport at Foz do Iguaçu is served by the commercial flights of several airlines.

2.2 Project layout

The general layout of the main permanent facilities of the Itaipu Project is shown in Fig. 1. Also shown are the two main cofferdams constructed to divert the Paraná River through the diversion channel during the construction of the main dam and the powerhouse in the river channel. The upstream cofferdam was not removed and was submerged by the reservoir. The top portion of the downstream cofferdam was removed however prior to start of operation of the generating units in the powerhouse.

*El = elevation in meters.

The overall project layout and the location and type of the principal structures were selected and finalized so as to satisfy the following basic considerations:

- Safety of the permanent facilities under all possible and realistic conditions during the entire operating life of the project.
- Economy of construction, operation and maintenance of the facilities.
- Compatibility with morphological, geological and hydrological conditions of the site.
- Facility of construction in order to complete the project according to the set schedules and targets.
- Optimum and economical utilization of materials obtained from excavation.
- Compatibility between the various phases of construction in order to avoid critical bottlenecks and/or duplication of work.

Four factors had the greatest influence on decisions regarding the layout of the project and the types of structures.

These were:

- Diversion of the river.
- Construction of the Spillway should not impede construction of the main dam and the powerhouse, and its operation should not have significant effects on the tailwater levels and energy production.
- Accommodation of the 18 generating units in a single powerhouse at the toe of the dam.
- Final closure of the diversion outlets and first filling of the reservoir.

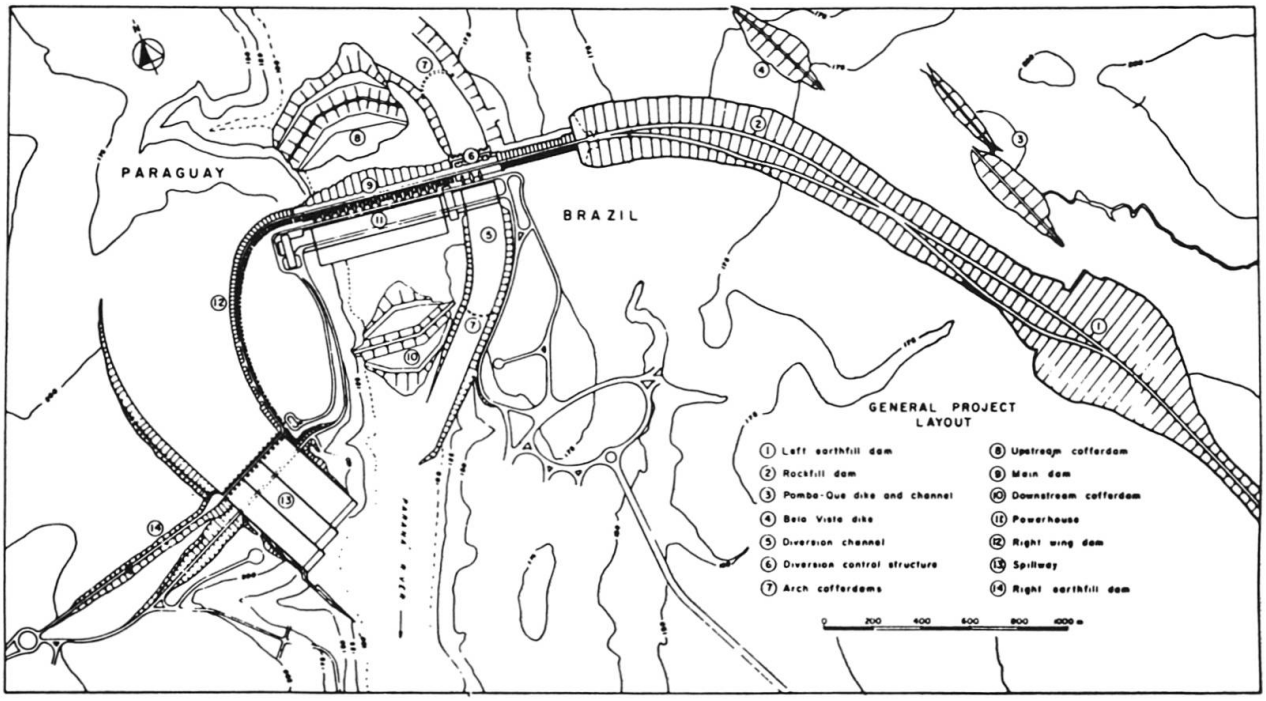


Fig. 1 General project layout

2.3 Main Project Features

The total crest length of the Itaipu Dam and Spillway is 7,744 m. The crest of all portions of the Itaipu Dam are at El. 225. The permanent dams of the Itaipu Project, from the right (western) to the left (eastern) bank and their crest lengths are:

- Right Earthfill Dam: 872 m
- Spillway Crest Structure: 390 m
- Right Wing Dam: 986 m
- Main Dam: 1,064 m
- Diversion Control Structure: 170 m
- Rockfill Dam: 1,984 m
- Left Earthfill Dam: 2,294 m

The Hernandarias Dike is a small dam, located in a low saddle along the rim of the reservoir about 3 km northwest of the Right Earthfill Dam.

Six temporary dams or cofferdams were also constructed.

These are:

- Bela Vista Dam
- Pomba Quê Dam
- Upstream Cofferdam
- Downstream Cofferdam
- Upstream Arch Cofferdam
- Downstream Arch Cofferdam

Of these, the first three were submerged by the Itaipu reservoir. The downstream cofferdam was partially removed to open up the tailrace channel of the powerhouse. The two arch cofferdams in the diversion channel were demolished during the diversion of the river in October 1978.

The powerhouse, located at the toe of the main dam and the diversion control structure has a total length of 968 m. From right to left, it is comprised of:

- Right Assembly Area
- 15 generating units in the main river channel
- Central Assembly Area
- 3 generating units in the Diversion Channel.

The powerhouse has two extra bays, one in the main river channel and the other in the diversion channel, which could accommodate generating units in the future, should it become feasible and necessary.

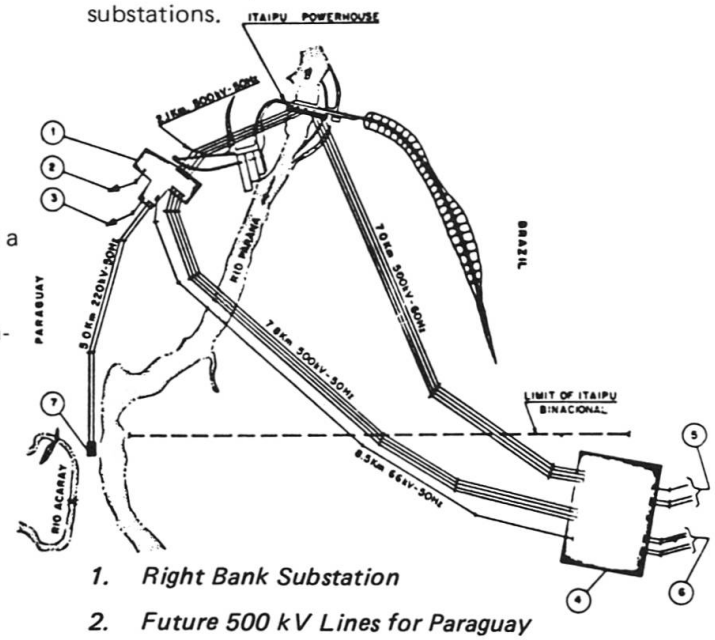
The three chutes of the spillway are located on the right bank, extending about 470 m downstream of the axis of its crest structure.

2.4 Power Transmission System and Substations

All power generated at the Itaipu Hydroelectric Project will be delivered to Paraguay and Brazil.

In order to meet the requirements of the two national systems, nine of the Itaipu units will generate power at 50 Hz and the other nine at 60 Hz. High voltage 18 kV to 500 kV step-up substations are installed at the powerhouse, with 50 Hz 500 kV lines connecting it to the Right Bank Substation, and 60 Hz 500 kV lines connecting it directly to the 500/765 kV AC step-up Substation at Foz do Iguaçu. Three 765 kV lines will transmit the power from this Substation to an EHV terminal substation near São Paulo.

Fig. 2 shows the physical aspects of the Itaipu transmission system and the locations of the substations.



1. *Right Bank Substation*
2. *Future 500 kV Lines for Paraguay*
3. *Future 220 kV Lines for Paraguay*
4. *Foz do Iguaçu Substation (Brazil)*
5. *765 kV, 60 Hz Lines for Brazil*
6. *DC Lines for Brazil (+ 600 kV)*
7. *Acaray Powerplant Substation (Paraguay)*

Fig. 2 Itaipu Transmission System

2.5 Basic Project Data

A summary of the more significant basic data regarding the various project features and facilities is presented in this section.

2.5.1 Hydrologic and Meteorologic Data

Drainage area of Paraná River Basin	820,000 km²
Streamflows recorded at Guaíra (1921-77):	
Average, daily	9,070 m³/s
Maximum, daily (on 3.3.29)	32,990 m³/s
Minimum, daily (11 to 16.10.44)	2,850 m³/s
In Paraná River Basin:	
Average annual precipitation	1,400 mm
Average annual evaporation	1,200 mm
In the Itaipu Project area:	
Average annual precipitation	1,650 mm
Average annual evaporation	1,000 mm
Average annual ambient temperature	21°C
Maximum ambient temperature	40°C
Minimum ambient temperature	-4°C

2.5.2 Reservoir

Maximum normal level	El. 220 m
Maximum flood level	El. 223 m
Minimum (exceptional) level	El. 197 m
Length	170 km
Surface area at normal pool level	1,350 km^2
Volume with maximum normal level	29 x 10^9 m^3
Useable volume	19 x 10^9 m^3

2.5.3 Power Capacity

Normal tailwater level	El.100 m
Maximum tailwater level	El.138 m
Maximum gross head	128 m
Normal gross head	120 m
Total installed capacity	12,600 MW
Firm capacity	9,360 MW
Average annual energy generation	79,000 GWh

2.5.4 Right Earthfill Dam

Crest length	872 m
Maximum height	25 m
Total volume	0.4 x 10^6 m^3

2.5.5 Spillway

Maximum discharge capacity	62,200 m^3/s
Length of control structure	390 m
Length of spillway (crest structure and chutes)	483 m
Total concrete volume	0.7 x 10^6 m^3
Radial gates: (Fig. 3)	
Number	14
Height	21.34 m
Design Head	20.0 m
Width	20.0 m
Stoplogs	2 sets, 6 panels each
Gantry Crane	1-785 kN

2.5.6 Right Wing Dam

Type of dam	Massive Head Buttress
Crest length	986 m
Maximum height	64.5 m
Number of blocks	58
Total volume (concrete)	0.8 x 10^6 m^3

2.5.7 Main Dam (Including Left Wing Buttress Dam)

Type of dam	Hollow Gravity & Buttress
Crest length	1,064 m
Maximum height	196 m
Number of blocks	44
Total volume (concrete)	5.2 x 10^6 m^3

2.5.8 Diversion Control Structure

Type of dam	Solid Gravity
Crest length	170 m
Maximum height	162 m
Total volume (concrete)	2.1 x 10^6 m^3
Diversion sluices:	
Number	12
Width	6.7 m
Height	22.0 m
Diversion Gates:	
Number	12
Width	8.23 m
Height	22.5 m
Maintenance (Auxiliary) Gates:	
Number	3
Width	7.18 m
Height	26.0 m
Stoplogs:	
Upstream	3 sets
Downstream	3 sets

2.5.9 Power Intakes and Penstocks

Number of intakes	20
Number of penstocks	18
Service gates:	
Number	18
Width	8.23 m
Height	16.35 m
Gantry cranes:	
Number	2
Capacity	1,110 kN
Penstock diameter	10.5 m

2.5.10 Rockfill Dam

Crest length	1,984 m
Maximum height	70 m
Total volume	12.8 x 10^6 m^3

2.5.11 Left Earthfill Dam

Crest length	2,294 m
Maximum height	30 m
Total volume	4.2 x 10^6 m^3

2.5.12 Powerhouse (including equipment assembly areas)

Total length	968 m
Width	99 m
Height	112 m
Top deck El.	144 m
Generator deck El.	108 m
Number of units	18
Unit spacing	34 m
Total volume of concrete	3.0 x 10^6 m^3

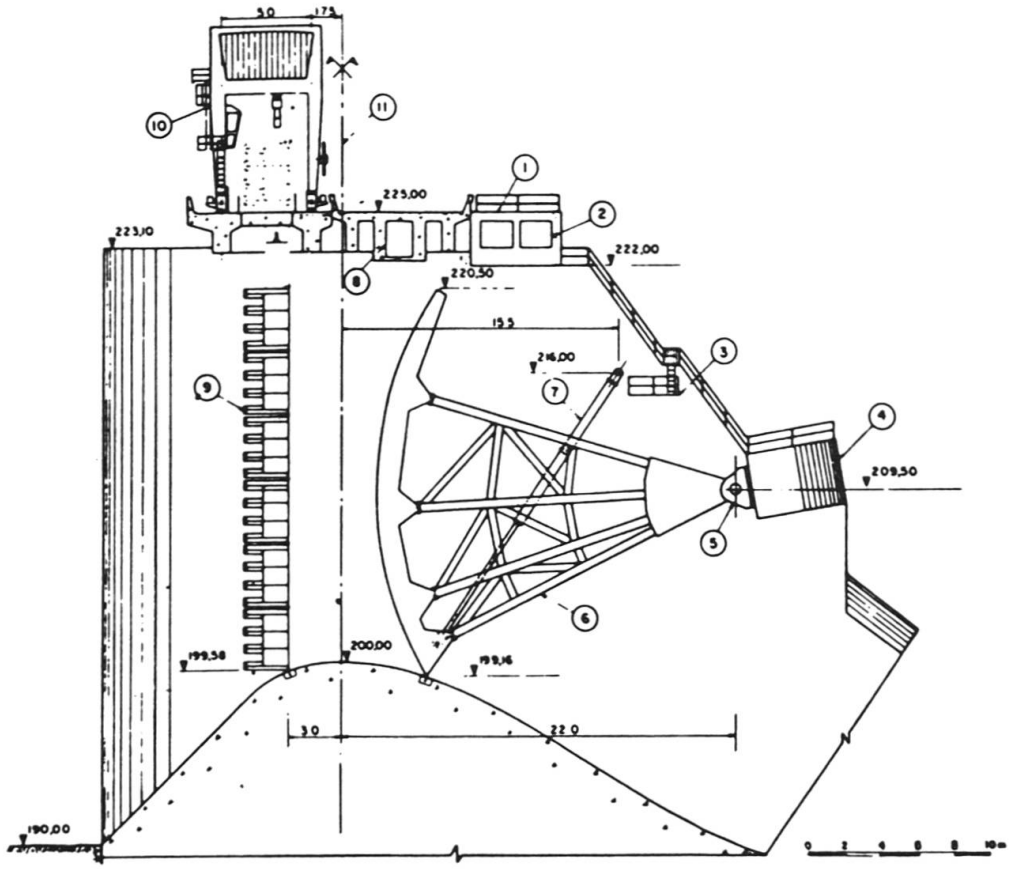
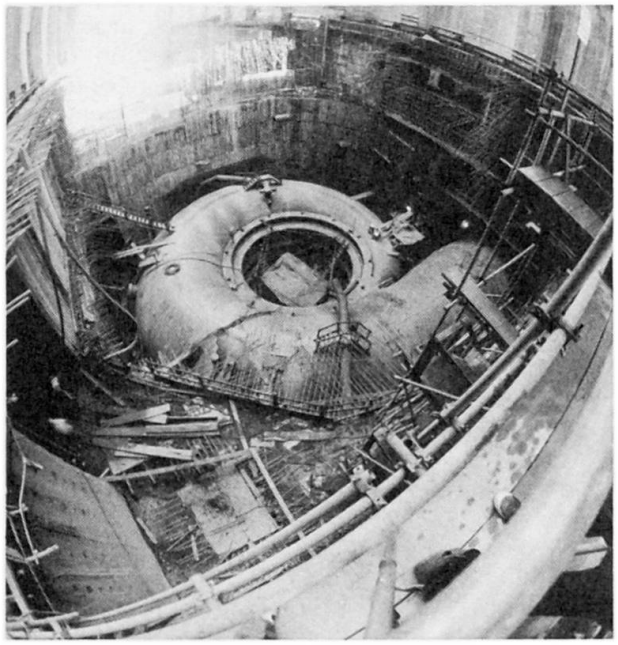
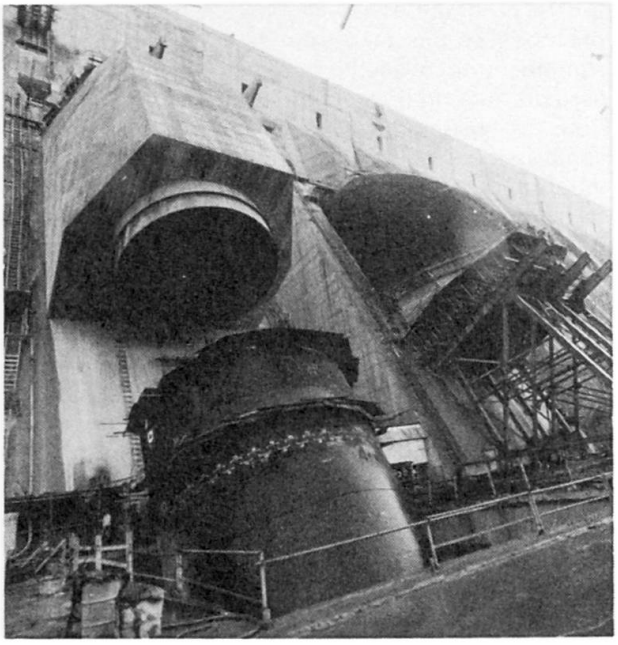


Fig. 3 Spillway Gates

1. *Access for equipment*
2. *Control room*
3. *Access platform to servomotor articulation*
4. *Trunnion girder*
5. *Trunnion thrust block*
6. *Tainter gate*
7. *Servomotor*
8. *Cable and hydraulic pipe gallery*
9. *Stoplogs*
10. *Gantry crane for lifting stoplogs*
11. *Spillway crest*



Spiral case



Power intake