

CHINA'S THREE GORGES DAM HYDRO-ELECTRIC POWER PLANT

by Peter Luxton

Last September Peter Luxton went on a thirteen day tour of China, which involved a cruise on the River Yangzi, during which a stop was made at the largest Power Station in the World, the Three Gorges Dam Project. He was extremely disappointed not to be allowed to visit the interior of the station, but managed to acquire many books on the subject and made further investigations resulting in the article below, for which we are very appreciative.

History

For many centuries, the Chinese have suffered huge loss of life when the River Yangtze flooded. For example, in the last 150 years there have been many floods with the following statistics:-

1870- 240,000 lives lost

1931-145,000 lives lost

1935- 142,000 lives lost

Even in recent times, 33,000 lost their lives in 1954 and 1526 people drowned in 1998.

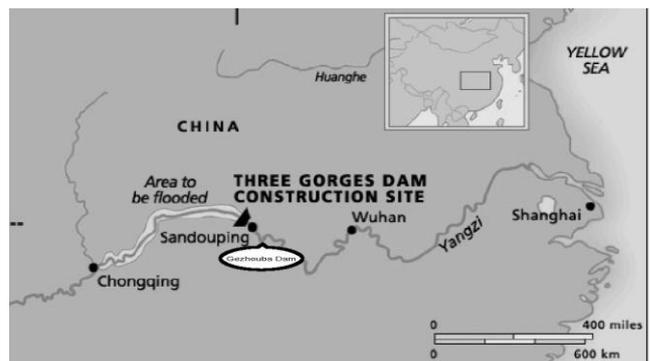
It was long ago in 1919 that Mr Sun Yat Sen proposed the building of a dam which would provide the following benefits:-

1. Flood Control over a major part of the river
2. Better Navigation for larger ships
3. The Provision of Hydroelectric power

It was not until 1944, when the Japanese war was still waging in China, that an American Dam expert Mr Lucien Savage visited the country and drew up detailed plans of a proposed dam. However due to the turmoil during the reign of Mao Tse Tung, it would be

1992 before the Chinese Congress gave the go ahead for the Three Gorges dam.

A smaller dam, the Gezhouba, had been constructed about 38 km downstream from the proposed 3 Gorges Dam which, although building had started in 1970, was not completed until 1989.



Location

Design

The total length of the 3 Gorges dam is 2,309.5 metres. Its total height is 185 metres giving a storage level of 175 metres. The dam has the following features :-

- 1- A 2 Channel 5 Stage lock system capable of handling ships up to 10,000 tons.
- 2- A Ship's Lift capable of handling ships up to 3000 tons.

3 - A Power station (Left Bank) with 14 generator sets - width 644 metres.

4 - A Spillway for flood control- width 483 metres.

5 - A Power station (Right Bank) with 12 generator sets - width 584 metres.

At a later stage (2002), it was decided to construct a further underground Power station with 6 additional sets.

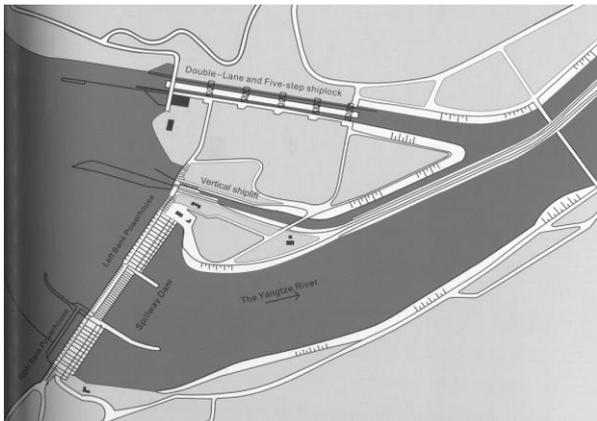


Diagram of Dam



A Model showing Features

The Generator Sets

Each generator set, the largest in the world, has a capacity of 700MW. In total there are 32 generators giving a capacity of 22,400 mW. In addition there are 2 "smaller" sets of 50 MW each which are used to power the plant. This is enough demand to supply a tenth of the power requirement for the whole of China. It is interesting to compare these figures with the total demand for UK which has peaked at 61.5 GW. It is estimated that the plant will provide 100 TWh per

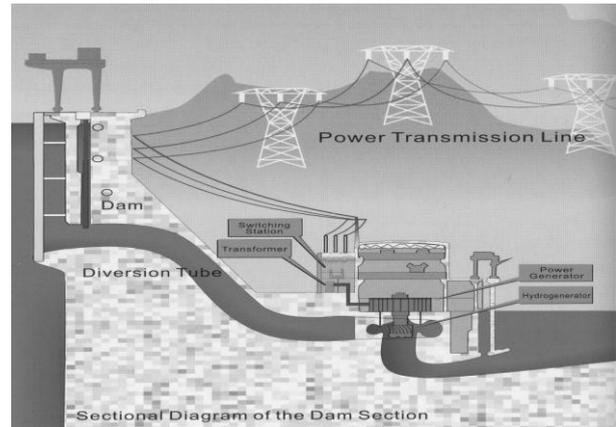
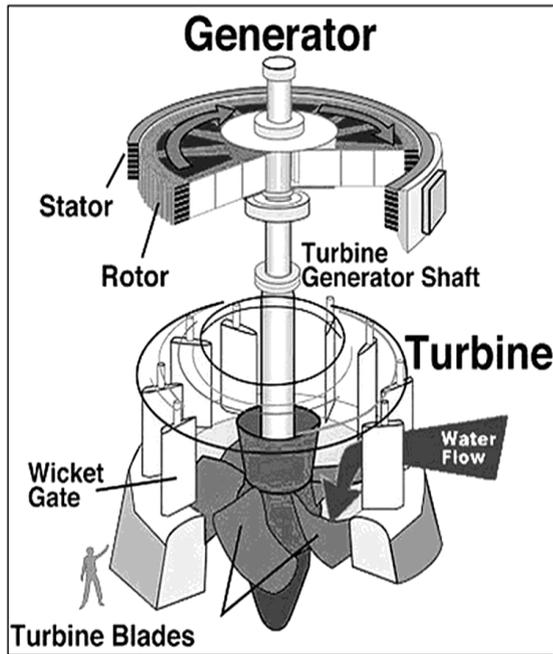
annum. The main generator sets weigh 6000 tons. The rotor weighs 1696.5 tons. Francis Turbines were used on the project. Although James B Francis was born in Britain in 1815 and developed his turbine in 1848 after emigrating to the USA, his design is still used on every hydroelectric project in the World. The Diameter of the Turbine is 10.4 metres and rotates at 75 rpm. The outer diameter of the stator is 21.4 metres and the inner diameter 18.5 metres. The height of the stator is 3.13 metres. The load on the main bearing is 5000 tons.

The generators were manufactured by 2 joint ventures. One of them includes Alstrom, ABB, Knaevor and a Chinese company Haerbin Motor. The other includes Voth, General Electric, Siemens and a Chinese company Oriental Motor. 8 of the 32 generators were built in China. Most of the generators are water cooled although some of the newer ones are air cooled which are simpler to design, manufacture and easier to maintain. The generator sets provide power at 20kV



The Cove and Rotor





By July 2012, the remaining 6 additional generators in the Underground Power Station were connected to the Grid. The project is now complete (2014) with the exception of the Ship Lift Lock which will be operational by the end of the year. It is estimated that the total cost of the project will be \$29 bn.

Dam Construction

The construction of the dam commenced in 1994 and was carried out in three phases. The three phases basically involved the three major diversions of the river so that ships could still progress in both directions. A whole chapter is required to itemise the progress but put simply:-

- Phase 1- 1994 to 1997
- Phase 2- 1998 to 2003
- Phase 3- 2003 to 2009

By 2003, the dam structure was completed and the reservoir filled to 135 metres. At this point, the first four generators were connected to the Grid.

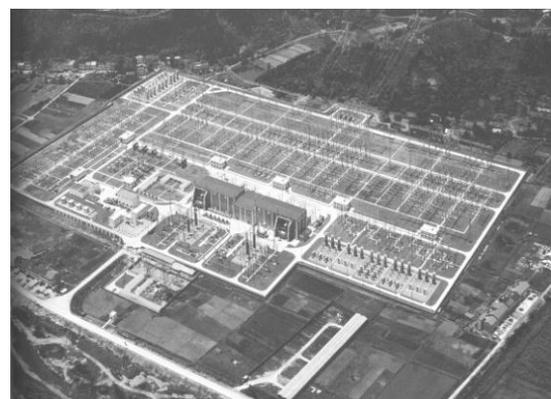
By 2004, all 14 generators in the Left Bank Powerstation were connected to the Grid. In 2006, the reservoir level was raised to 156 metres.

By 2008, the reservoir level was raised to 175 metres and the remaining 12 generators in the Right Bank Powerstation were connected bringing all 26 units in the main dam up to power.

Distribution



Control Room



The Main Substation

Electricity generated is sold to the State Grid Corporation and the China South Power Grid.

In all, nine provinces and 2 cities consume power from the dam including Shanghai which is 1000km away. The power distribution costs were \$9 bn . The work was completed in 2007 a year ahead of schedule.

Power is sent in three directions. Maximum capacities of the line are shown below :-

- 1 500kV DC line to the East China Grid (7200 MW)
- 2 3 X 500 kV DC lines to the Shanghai Area (7,200 MW)
- 3 500 kV DC line to the South China Grid (3000 MW)
- 4 500 kV AC line to the Central China Grid (12000 MW)



The Switchgear

Other Interesting Data

1 The new reservoir from the 3 gorges Dam to Chongqing is 414 mile long and has a depth of 175 metres. It was necessary to flood 12 major cities, 140 towns, 326 townships and 1500 villages to create the reservoir. A total of 1.3 million people had to be relocated either to completely new towns or accommodated in nearby large cities.

2 The first hydroelectric Plant in China was built in 1912 at Shilong Dam (Yunnan Province). It had a capacity of 500 KW. In theory, it would be possible to provide 448 GW

of power from hydro in China. There is an ongoing programme to provide hydro power with an aim of providing 26% of the demand by 2020.

At present, the main source of power (80%) in China is from coal fired stations which are still being built at an alarming rate. However the 3 gorges project will save the use of 31 million tons of coal per annum. Besides the environmental issues, savings are also made because the coal does not have to be mined, washed, and transported from the north of China on the overstretched railways. The USA is still the largest polluter of the atmosphere in the World but China is now a close second in the league.

3 The 3 gorges Hydroplant is the largest in the World by a long way. The next largest is the Itaipu Dam in Brazil with a capacity to provide 12.6 GW.

4 The river Yangtze is the third longest river in the World (6,300 Km). The new dam will improve transport on the river for it is now possible for 10,000 ton ships to navigate to Chongqing (a city of over 10 million people) a distance of 2,000 Km from Shanghai.

5 Flood Control. Since the Tang dynasty 2300 years ago, there have been 214 major floods ie almost one every ten years. The reservoir flood storage capacity is such that the chance of major catastrophic flood has been reduced from one in ten years to one in one hundred years.

6 On the downside, there are some concerns. The dam is in an earthquake area.

The Zigua- Badong fault is 50 miles upstream which as recently as 2003 had an earthquake Richter Scale 3 although Richter Scale 6 has occurred in the past. The dam has been designed to withstand a earthquake Richter Scale 7.

Although hopefully unlikely, the dam has been built to withstand an attack if there was a war situation. Another major concern is sedimentation. This has been a major problem on previous dam projects. Critics of the project anticipate that due to siltation, the ports , like Chongqing will clog up and the Yangtze will be impassable.

Another sad statistic is that over 100 workers have lost their lives during the construction of the dam.



Turbine Hall

Gezoubaba Dam

As mentioned in the first chapter, a "trial" dam had been constructed 38Km downstream of the new dam and came into operation in 1989.

The Gezouba Dam is 2606 metres long (longer than the 3 gorges!!) with a height of 70 metres.



Gezoubaba Dam

There are 3 single stage ship locks 2 of which can accommodate 10,000 ton ships. There are two hydroelectric power stations with 21 generators providing a demand of 2.7 GW.

Two "hundred year" floods were encountered in 1981 and 1998 and the dam is safe and sound.

Final Comment

We were told by the site guide that by the end of the year (2014), the sale of electricity will have already paid for the capital cost of the project.

The demand for electricity in China has increased so much over the last 20 years that although it was anticipated at the planning stage in 1993 that the dam would provide 10% of China's needs by 2014, the figure is in reality catering for only 3% of the demand.