International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 02, February-2019

COMPREHENSIVE STUDY ON VARIOUS CHALLENGES ENCOUNTERED DURING THE CONSTRUCTION OF THE THREE GORGES DAM AND THEIR MITIGATION

Arsalan Farooq

Assistant professor, Department of Civil Engineering, Islamic University of Science and Technology, Awantipora

Abstract: ***The Three Gorges Dam has been built to provide hydroelectricity, flood control, and greater navigation access to the Yangtze River in central China. It is responsible for bringing both unprecedented benefits and risks to the people of the China in general and Yangtze River Valley in particular. The paper presents in detail the challenges faced during construction of one of the largest hydroelectric dam, Three Gorges Dam. For constructing dam, large volume of water has to be diverted. Construction of coffer dam and dismantling it was in itself a huge task. Large amount of concrete was used to build the dam which resulted in generation of large quantity of heat of hydration. The foundation is prone to failure due to presence of large volume of water stored upstream of the reservoir. The foundation rests on weak soil making it more prone to failure. Silting is another issue which can effect efficiency of Power plant. The dam is located in area which is prone to landslides and earthquake. As such area is continuously monitored for any hazard and mitigation.***

Keywords: Yangzte river; coffer dam; mass concreting; foundation; silting; failure; landslide; earthquake.

1. Introduction:

The Three Gorges Dam is located in China's rural heartland on the third largest river, Yangtze as shown in Fig 1. It has a height of 182 m and length is 2.4 km. 400 km reservoir is located on its upstream end. It is one of the largest power station. It has played a crucial role in meeting the energy demands of China's population. The dam has greatly reduced the severity of floods. 28 million cubic meter of concrete and 463000 tons of steel was consumed during its construction. Total cost of construction is US $22.5 Billion.

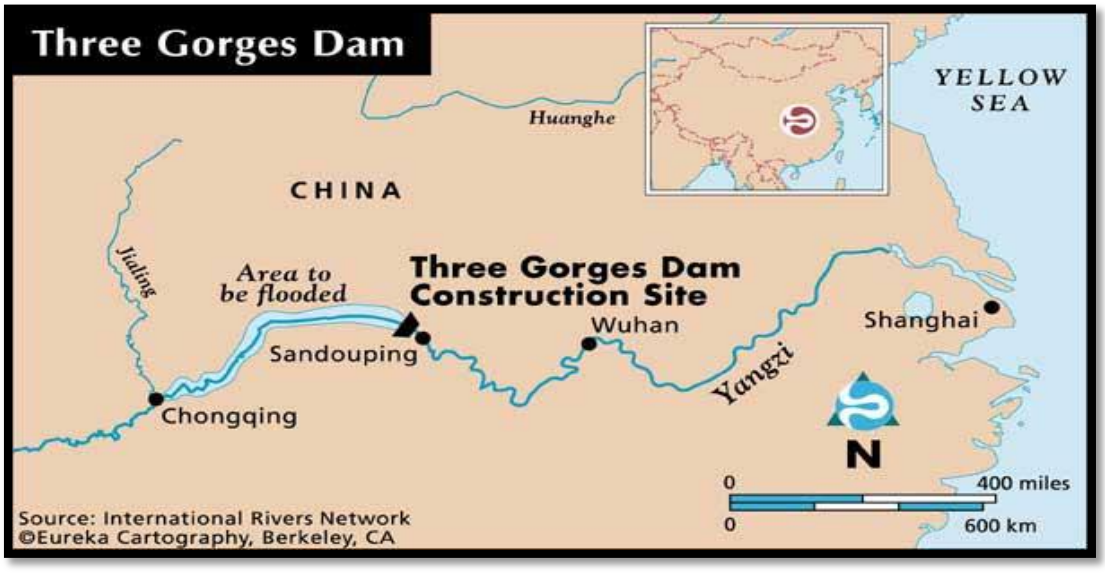

Fig 1: Location of the Three Gorges Dam

2. Challenges Encountered During the Construction of Three Gorges Project (TGP):

2.1. Diversion of river water: The width of dam is 2 km. As such it was difficult to divert such a large volume of water. To address this issue coffer dams were constructed. First coffer dam was made up of stone to block water. A channel was left open for the rest of river to flow as shown in Fig 2. Later concrete coffer dams were built. The concrete coffer dam had holes

in it which on completion of dam were filled with dynamite to dismantle it. 190 tons of dynamite were put in coffer dam and blown in 13 seconds. The impact is enough to topple 400 10-storey buildings.

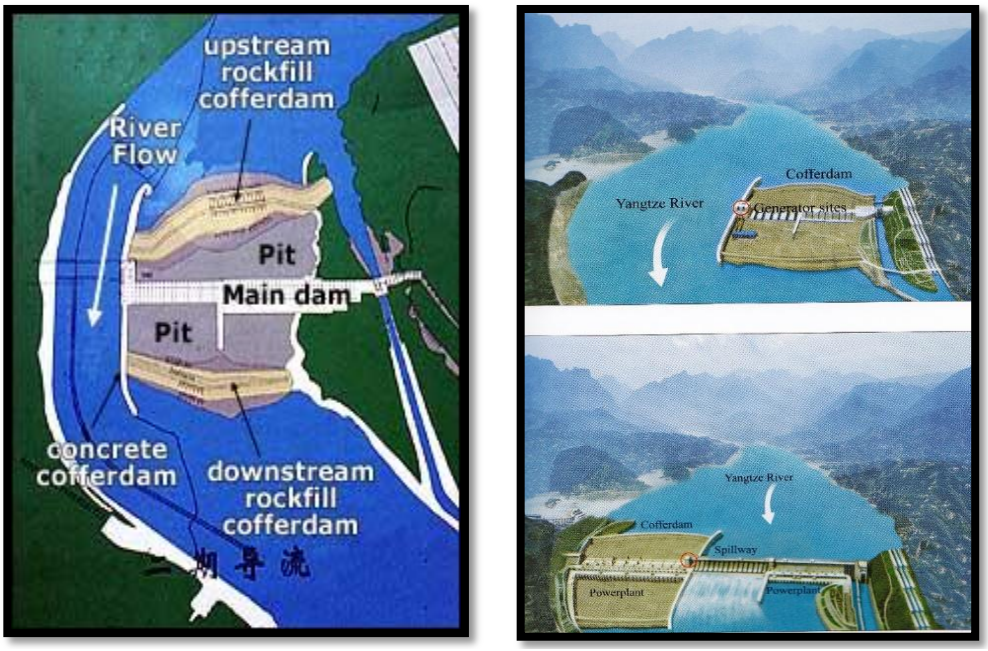

Fig 2: Construction of Coffer Dam

***2.2: Mass concreting**:* For the construction of hydropower 28 million tons of concrete was used. During the hydration, large amount of heat is generated. If this heat doesn't escape cracking in concrete occurs. In order to address this issue various techniques were incorporated. The aggregates were cooled, ice was added to keep temperature low. During harsh summer season fog spray system was introduced over the top of the dam with the objective of blocking solar radiations. A network of steel pipes was placed inside the concrete mass. Water at low temperature was continuously circulated to remove excess heat.

2.3: Damage by floods: The Three Gorges Dam holds large volume of water behind. During the floods it has a capacity to hold 22 billion cubic meter of water. If this water is released it can cause dam failure. This issue has also been addressed. Water is released in controlled manner through system of 46 go away gates and chutes. The spillway is designed to deal with water force as it drops from the height of 100m. It achieves huge velocity at the bottom of the dam. To deflect the force of water crashing down, engineers used technology similar to Grand Coulee dam. As the water level rises engineers open a series of gates to drain the flood water from the reservoir. If water falls straight it could undermine the foundation of the dam. So the engineers filled gates with concrete to form a ramp. The Three Gorges Dam ramps are above the water level. Water is hurled into the air. Once airborne the water breaks up into small droplets and losses much of its destructive energy. It lands over 100m downstream where it cannot do any damage.

Fig 3: Removal of excess water during floods

***2.4: Navigation facility*:** The Yangtze River is one of the busiest routes in Asia. 18 million tons of freight is being carried along it in a year. To meet this demand Ship Lock and Ship Lift have been provided (Fig 4). 170 ships carrying cargo and passengers pass through dam every day. The freight is carried through Ship Lock. Ships have to go through 5 tier of locks. It

takes 5 hours for the ship to cross the dam. To carry passengers across the dam Ship Lift is used. It is provided with massive counterweighs to do lifting. 16, 1000 ton concrete blocks are connected by cable to the steel. They carry the ship and the water that floods in. As the counterweights drop they hoist the trough upwards and lift ship to the top. It takes 36 minutes to lift the elevator. The Ship Lift is 113m high and can handle vessels up to 3000 tons, making it largest in the world.

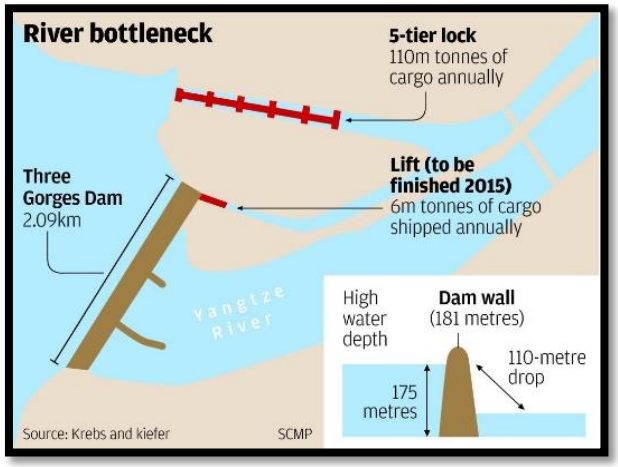

Fig 4: Location of shiplift and shiplock

2.4: Excessive Sedimentation*:* The flow of silt is blocked and trapped in the reservoir. It rapidly sinks to the bottom where it gets accumulated. Removal of this silt is a huge challenge. Nearly 500 million tons of silt which equals to 1 km^2 is deposited every year. This silt remains trapped behind and effects agriculture on the downstream side. It is also responsible for reducing reservoir capacity. To address this challenge the engineers use power of flood water to flush sediment out of reservoir. Sluice gates are placed deep inside the dam. The heavy gates need powerful hydraulic pistons for lifting purpose. When operators open the gates flood water flushes the trapped sediment and sweeps it through the dam. However the amount removed varies from 30- 60 % of total silt by different estimates.

2.5. Landslide: The area surrounding the dam is prone to landslides. Raising and lowering of water in the dam reservoir intensifies this effect. Lainziya rock mass and Xintan landslide are situated on the banks of Yangtze River 16 miles upstream of dam. These are responsible for landslides of great devastation. At least 14 old landslides are considered likely to be reactivated by the filling of the reservoir. In order to monitor the landslides, 4 corner reflectors have been installed on the Xintan landslide slope and 6 on the Lianziya hazardous rock mountain. These reflectors are connected to INSAR. The banks are also strengthened with concrete.

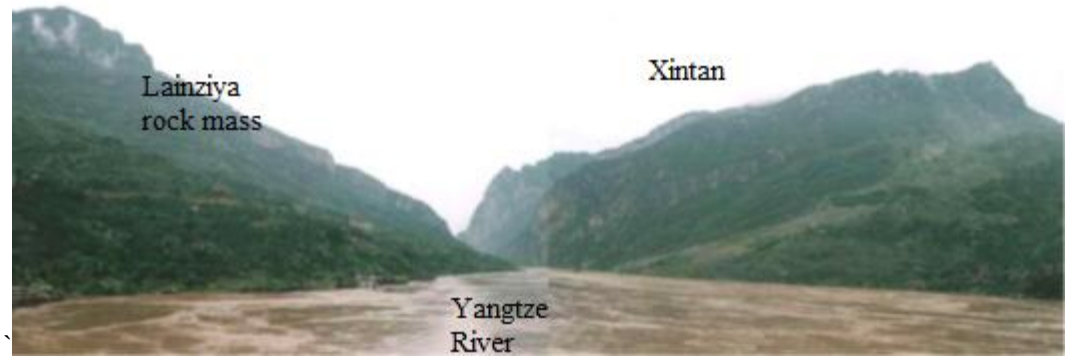

Fig 5: Landslide prone area along Yangtze River

2.6. Earthquake Hazard**:** The most serious threat to the structural integrity of the Three Gorges Dam is due to earthquake including Dam induced seismicity. The dam is situated in an area where 6 fault lines are present. After filling reservoir to 135m seismic activity increased. Few minor tremors were recorded. Earthquakes can also be caused due to collapse of limestone (karst) caves left over from mining activities. The Three gorges Dam has been built to withstand earthquake of magnitude 7. A network of 21 digital earthquake monitoring stations has been set up in the Chongqing section of the Three Gorges Reservoir. Costing 29.6 million Yuan (3.7 million U.S. dollars), the stations monitor seismological activity round the clock and provide an earthquake warning system. This can help in mitigating the damage to some extent.

3. Conclusion:

The Three Gorges Dam project is the symbol of China's technological superiority. The Three Gorges Dam (TGD) and associated infrastructure is the largest integrated water project built in the history of the world. During the design and construction of the Three Gorges Project, large number of technological, environmental and social issues were confronted. Most of these have been addressed by cross-industry collaborative innovation. The technological innovations developed during The Three Gorges Project has been widely applied for development of hydroelectric power projects around the world. These have helped in providing access to clean energy and reduced dependency on non-renewable resources.

References:

[1] Canadian International Project Managers (CIPM) Yangtze Joint Venture (CYJV), Three Gorges Water Control Project Feasibility Study, August 1988.
[2] China Yangtze Three Gorges Project Development Corporation. (1999, February). Three Gorges Project, Yichang Hubei Province, China.
[3] EMergy accounting for the Three Gorges Dam project: Three scenarios for the Estimation of Non-Renewable Sediment cost Juan Yang School of Marine Science, China University of Geosciences.
[4] Geographical Overview of the Three Gorges Dam and Reservoir, China—Geologic Hazards and Environmental Impacts. U.S. Geological Survey. Open-File Report 2008–1241.
[5] Han, Z.S., 1988, Landslides and Rockfalls of the Yangtze River Gorges: Beijing, Geological Press.
[6] Ian Reynolds impact of Three Gorges dam Johnson County Community College, JCCC Honours Journal.
[7] Key Technologies of the Hydraulic Structures of the Three Gorges Project Xinqiang Niu Changjiang Institute of Survey, Planning, Design and Research, Wuhan 430010, China.
[8] The Three Gorges Dam of China: Technology to Bridge Two Centuries Wafeek S. Wahby , The journal of technological studies.
[9] The World's Water 2008-2009: The Biennial Report on Freshwater Resources By Peter H. Gleick, Michael J. Cohen
[10] Wang, J., Li, S., Yan, L., and Dong, D., 2002, Preliminary analysis on the May 1, 2001, landslide at Wulong of Chongqing City: Engineering Science.